Vol. 36 No 5

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY, 1909

Nitrogen assimilation of Sterigmatocystis nigra and the effect of chemical stimulation *

MARION E. LATHAM

Inasmuch as the question of the relation of unstimulated and stimulated crops of *Sterigmatocystis nigra* to their carbohydrate supply had been several times investigated by Professor Richards and his students, it was decided to look into the effect of chemical stimulation upon the nitrogen consumption. Upon examination, it was found that this led largely to a study of the question of nitrogen fixation by the fungus under varying conditions, with the results given below. It will be remembered that Richards † determined the optimum stimulation for various salts; that Watterson ‡ worked over the effect of such stimulation on the CO_2 given off; that Richards § also determined the effect of irritation on the relative sugar consumption; and the present writer ‖ worked along the same line and also considered the amount of oxalic acid excreted. This present paper is offered as a contribution to our knowledge of the nitrogen metabolism of *Sterigmatocystis nigra*. It has been carried out in the Botanical Laboratories

* The investigations here reported upon have been aided by a grant made to H. M. Richards from the Esther Herrman Fund of the New York Academy of Sciences.

† Richards, H. M. Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. **30**: 665. 1897.

‡ Watterson, A. The effect of chemical irritation on the respiration of fungi. Bull. Torrey Club **31**: 291. 1904.

§ Richards, H. M. The effect of chemical irritation on the economic coefficient of sugar. Bull. Torrey Club **26**: 463. 1899.

‖ Latham, M. E. Stimulation of *Sterigmatocystis* by chloroform. Bull. Torrey Club **32**: 337. 1905.

[The BULLETIN for April, 1909 (**36**: 177–234. *pl. 12–17*) was issued 4 My 1909.]

of Barnard College with the aid and advice of Professor Richards, to whom the writer is pleased once more to be able to acknowledge indebtedness and gratitude. A grant from the Esther Herrman Fund supplied some of the special apparatus used in prosecuting the work.

In 1895 Puriewitsch * published the results of an investigation on the nitrogen-fixing power of *Aspergillus niger* (*Sterigmatocystis*) and *Penicillium glaucum*, concluding that both organisms are able to bring uncombined nitrogen into chemical union, the amount so combined being in direct proportion to sugar supply and bearing no definite relation to the dry weight of the fungal felt. This work has been brought to question by various commentators † because of the small amount of nitrogen determined in analyses and the large chance of error inherent in the Kjeldahl method. Puriewitsch ‡ in his cultures used phosphoric acid in minute quantity to inhibit the growth of any nitrogen-fixing bacteria, not being sure, it seems, of his stock of the fungus. It has been indicated by the results that follow that the presence of this phosphoric acid will account for the small amount of nitrogen combined by the fungus, since the mycelium was stimulated by the acid and the ability to fix atmospheric nitrogen at the same time diminished.

Saida § has recorded a gain in total nitrogen in compound when working with *Aspergillus;* Winogradsky || had none. Berthelot ¶ had written in 1893 that he found a fixation of nitrogen by *Aspergillus niger*, *Alternaria tenuis*, and *Gymnoascus;* but of these only the *Alternaria* culture was pure and there the gain reached as high as 98 per cent. of the original nitrogen content. Brefeld ** investigated the action of *Ustilago*, which he found did not assimilate free

* Puriewitsch, K. Ueber die Stickstoffassimilation bei den Schimmelpilzen. Ber. Deuts. Bot. Gesells. **13**: 342. 1895.

† Lafar, F. Handbuch der Technischen Mykologie **3**: 1–69. 1904–1906.
Czapek, F. Biochemie der Pflanzen **2**: 125. 1905.
Jost, L. Plant Physiology, 235. 1907. [English translation.]

‡ Puriewitsch, K. *Loc. cit.*

§ Saida, K. Ueber die Assimilation freien Stickstoffs durch Schimmelpilze. Ber. Deuts. Bot. Gesells. **19**: 107. 1901.

|| See Lafar, F. Handbuch der Technischen Mykologie **3**: 11.

¶ Berthelot, M. Recherches nouvelles sur les microrganismes fixateurs de l'azote. Comptes Rendus **116**: 842. 1893.

** Brefeld, O. Versuche über die Stickstoffaufnahme bei den Pflanzen. Centralb. für Bakt. II. **8**: 24. 1902.

nitrogen and, furthermore, had no part in aiding the action of the host. In the case of *Phoma*, Saida * confirms Puriewitsch's conclusions with regard to the proportion between the amount of nitrogen brought into combination and the sugar at hand; and moreover, he records that when the fungus is growing on a solution poor in nitrogen compounds, then the CO_2 evolved becomes greater, that is, a greater expenditure of energy is indicated. Ternetz † found a gain in combined nitrogen due to the activity of a fungus isolated from the roots of *Oxycoccus*.

This summary of the work done on the relation of fungi to nitrogen-fixing is intended to touch the main points only. The literature may be had in detail from the works of Czapek ‡ and Lafar § and we are therefore content with this brief citation. The same question with bacteria has, of course, been more widely worked over, but with it we have made no attempt to deal.

In our former work, gaseous chloroform was the reagent used as a stimulant, but in this case we had recourse to zinc sulphate in solution, a stimulant with which Richards || had earlier worked. This was both because the difficulties in manipulation with the gas added to those of Kjeldahl analysis would probably have taken more time than we could hope to give to the work, and also because zinc sulphate has been more often used as a stimulant and its action is better known. The principle in each case is the same so that results would be similar. Aside from the difference in stimulant, the same methods were used as previously, the same superior reagents and insoluble glass, and the same care in preparation. A careful plate culture was prepared with the nutrient media in the gelatine to test the purity of the *Sterigmatocystis*. This showed no trace of bacteria whatever, so it was concluded that the spores were bacteria-free or at worst so little contaminated as to be highly satisfactory for our work. The growing cultures were kept under sealed bell-jars in order to exclude influences other than the one under observation, since we had found that the fungus is very sen-

* Saida, K. *Loc. cit.*

† Ternetz, C. Assimilation des atmosphärischen Stickstoffs durch einen torfbewohnenden Pilz. Ber. Deuts. Bot. Gesells. **22**: 267. 1904.

‡ Czapek, F. *Loc. cit.*

§ Lafar, F. *Loc. cit.*

|| Richards, H. M. *Loc. cit.*

sitive to traces of gases in the atmosphere. The recipe of the culture solution is this:

1.00 gm. NH_4NO_3	5.00 gm. sugar
0.50 " KH_2PO_4	100 c.c. water
0.25 " $MgSO_4$	trace of iron

The solution was made up in bulk in carefully cleaned and sterilized "non-sol" glass, boiled, cooled, and a suitable quantity taken at once for determining the nitrogen content. The rest was sown with spores, and zinc sulphate added in measured quantities where desired. The cultures were then allowed to grow for five or six days to reach a proper state, when they were reaped, the substratum analyzed at once for nitrogen, and the felts washed and dried preparatory to their analyses. In making all measurements, accurate pipettes and burettes were used, and for weighing the dry felt, a good Becker balance. To ascertain the nitrogen present the Gunning-Jodlbauer modification of the Kjeldahl process was followed. Two felts were cultivated at each stimulation and two determinations of nitrogen were made on each solution and on each felt. The procedure was to analyze the solution as provided to the fungus and again immediately after the crop was reaped, any difference being attributed to the action of the fungus. Then the dried felt was analyzed and the results obtained here added to the others and thus the full amount of nitrogen present in chemical union was determined. The most marked change is visible in the fluid substratum, because *Sterigmatocystis*, like nitrogen-fixing bacteria, may under favorable conditions excrete as a waste product some of the nitrogen compounds which it has formed from gaseous atmospheric nitrogen. The amount to be found in the make-up of the fungus itself being, as we find, relatively the same under all circumstances.

From six series grown after methods had been mastered, it was seen that (1) *Sterigmatocystis* grown normally does fix free nitrogen which is found to be in combination if nitrogen compounds be supplied in favorable quantity; (2) the amount of nitrogen so combined decreases if the culture be subjected to stimulation, both absolutely and relatively, *i. e.*, both in absolute quantity and in amount per gram of dry weight of crop produced, the diminution being shown most markedly by the decrease in combined nitrogen

in the substratum, where the amount of nitrogen fixed may become negative, that is to say, from which nitrogen may be used in metabolism ; (3) the amount of nitrogen entering into the composition of the felt remains relatively the same in normal and stimulated growths ; (4) the optimal stimulation from a carbohydrate point of view is not marked in nitrogen fixation where there is a gradual decrease in the amount caused to combine. These six series are wholly consistent within themselves.

TABLE I

Series.	Stimulation in terms of normal $ZnSO_4$ solution	Net dry weight Mg.	A Nitrogen furnished each culture Mg.	B Total nitrogen in each culture solution after growth Mg.	B—A Nitrogen fixed in each culture solution Mg.	Mg. of nitrogen fixed in solution per gram of felt	C Nitrogen in felt Mg.	Mg. of nitrogen per gram of dry felt	B + C Total nitrogen in felt and solution Mg.	B + C — A Total nitrogen fixed Mg.	Total nitrogen fixed in Mg. per gm. of dry felt
1	0.0000	200.2	115.4	175.8	60.4	301.5	11.1	55.5	186.9	71.5	357.2
	.0005	740.8		116.3	0.9	1.2	45.8	61.8	162.1	46.7	63.04
	.00075	722.6		112.2	—3.2	—4.5	69.3	63.5	181.5	66.1	91.47
	.001	767.5		112.6	—5.6	—7.4	44.9	58.5	157.5	42.1	54.85
2	0.0000	302.8	117.7	311.3	193.6	639.4	11.5	38.0	322.8	205.1	677.3
	.0003	740.5		118.4	.7	1.0	45.1	61.0	163.5	45.8	61.85
	.0005	705.5		144.7	27.0	38.3	44.2	62.6	189.1	71.4	101.20
	.0007	630.0		130.7	13.0	20.6	40.0	63.5	170.7	53.0	84.14
3	0.0000	185.0	141.6	132.8	—8.8	—47.6	10.4	56.1	143.2	1.6	8.65
	.0003	751.0		158.5	16.9	22.5	43.0	57.2	201.5	59.9	79.76
	.0005	705.0		150.0	8.4	11.9	43.8	62.2	193.8	52.2	74.04
	.0007	698.9		148.5	6.9	9.9	43.7	62.5	192.2	50.6	72.40
4	0.0000	270.0	155.1	185.2	30.1	111.5	14.9	55.4	200.1	45.0	166.8
	.0003	763.3		139.4	—15.7	—20.6	45.3	59.4	184.7	29.6	38.78
	.0005	773.0		146.9	— 8.2	—10.6	45.0	58.2	191.9	36.8	47.61
	.0007	772.4		129.4	—25.7	—33.3	40.3	52.1	169.7	14.6	18.90
5	0.0000	420.9	156.3	173.9	17.6	41.8	20.4	48.4	194.3	38.0	90.28
	.0005	728.9		146.8	— 9.5	—13.0	44.1	60.4	190.9	34.6	47.46
	.001	685.2		147.0	— 9.4	—13.7	35.0	51.1	182.0	25.7	37.51
	.0015	662.5		120.2	—36.1	—54.5	40.0	60.3	160.2	3.9	5.89
6	0.0000	316.5	160.3	115.4	—44.9	—141.9	11.6	36.6	127.0	—33.3	—105.2
	.0003	769.7		79.8	—80.5	—104.6	46.5	60.3	126.3	—34.0	—44.17
	.0005	853.7		65.8	—94.5	—110.7	52.0	60.3	117.8	—42.5	—49.78
	.0007	765.5		72.9	—87.4	—116.8	47.3	61.8	120.2	—40.1	—52.38

It may be seen by reference to Table I that with the control crops, those under normal conditions and without stimulation, there was found an increase of nitrogen over that of the initial

amount of nitrate that varied from 205.1 milligrams to 1.6 mg.; the amount supplied varying at the same time from 115.4 mg. to 156.3 mg. When the supply passed beyond the optimum point, when in this case 160.3 mg. were given the fungus at the outset, nitrogen was consumed. This would seem to indicate that the critical point with regard to nitrogen supply is slightly below 160.3 mg. in 50 c.c. of solution, although no attempt was made to determine the critical point with accuracy. It is known in the case of other nitrogen-fixing organisms that with an increasing nitrogen supply, the ability to utilize free nitrogen becomes less and less. At the point where it ceases, nitrogen must, of course, be consumed in the growth of the fungus. It will be noted how great is the difference between the amount of nitrogen fixed by the series just below the one in question and those with a much less amount supplied in the culture fluid. As the curve of nitrogen supply rises the curve of nitrogen-fixing ability falls, until the two cross at a point at which nitrogen consumption will begin. It may very well be that along such lines lies the inability of *Azotobacter* to fix nitrogen, ascribed by Beijerinck * to unexplained internal causes.

The average of the normals of all six series is 54.7 mg. or 199 mg. per gram of dry weight of the fungus felt; excluding from the average the series in which nitrogen was consumed, that is, series 6, the average becomes 72.2 mg. of nitrogen fixed, which is equivalent to 260.1 mg. per gram weight of dry crop. This union of atmospheric nitrogen diminishes with stimulation, being fairly constant around the point of optimal stimulation —.0005N $ZnSO_4$ — but finally disappearing. With a .0005N solution of $ZnSO_4$, the amount of nitrogen brought into combination varies from 34.6 mg. to 71.4 mg., the average being 48.3 mg. and this is 66.6 mg. per gram of dry felt produced. The effect of chemical stimulation upon nitrogen assimilation is therefore obvious at a glance if we compare normal and stimulated results, 72 mg. or 260.1 mg. per gram of dry felt in the unstimulated as against 33.2 mg. or 66.6 mg. per gram of dry substance in the stimulated. And again to compare the highest figures obtained at each point, a total gain of 174.2 per cent. of nitrogen over the amount supplied the normal

* Beijerinck, W. Centralb. für Bakt. II. 7: 561. 1901.

crop *versus* 60.6 per cent. gain in the crop grown at the optimal stimulation.

As was said before, commentators in their reviews have made objection to the work on nitrogen combination by fungi on the ground that the amounts determined by the analysis were too

TABLE II

AVERAGES OF FIVE SERIES, SERIES 6 BEING OMITTED

Stimulation in terms of normal $ZnSO_4$ solution	B − A Total nitrogen fixed in each culture solution Mg.	Mg. of nitrogen fixed in each solution per gram of felt	C Nitrogen in felt Mg.	Mg. of nitrogen per gm. of dry felt	B + C Total nitrogen in felt and solution Mg.	B + C − A Total nitrogen fixed Mg.	Total nitrogen fixed in Mg. per gram of dry felt
.0000	58.6	209.3	13.7	50.7	209.5	72.2	260.1
.0003	.6	1.0	44.5	59.2	183.2	45.1	60.2
.0005	3.7	5.6	44.6	61.0	185.6	48.3	66.7
.0007	— 2.2	— 1.8	48.3	60.4	178.5	46.1	66.7
.0010	— 7.5	—10.5	39.9	54.8	169.8	33.9	46.2
.0015	—36.1	—54.5	40.0	60.3	160.2	3.9	5.9

TABLE III

GRAND AVERAGES OF ALL SERIES

Stimulation in terms of normal $ZnSO_4$ solution	B − A Total nitrogen fixed in each culture solution Mg.	Mg. of nitrogen fixed in each solution per gram of felt	C Nitrogen in felt Mg.	Mg. of nitrogen per gm. of dry felt	B + C Total nitrogen in felt and solution Mg.	B + C − A Total nitrogen fixed Mg.	Total nitrogen fixed in Mg. per gram of dry felt
0.0000	41.3	150.8	13.3	48.3	195.7	54.7	199.2
.0003	—19.7	—25.4	45.0	59.5	169.0	25.3	34.1
.0005	—12.7	—13.8	45.8	60.9	174.3	33.2	47.3
.0007	—19.3	— 24.8	48.1	60.7	166.9	28.8	42.9
.0010	— 7.5	— 10.5	39.9	54.8	169.8	33.9	46.2
.0015	—36.1	—54.5	40.0	60.3	160.2	3.9	5.9

small to be due positively to anything but experimental error. Now Puriewitsch's largest analysis gave 18.2 mg. of nitrogen with 9.8 mg. supplied at first, making a gain in fixed nitrogen of 8.4 mg. Saida's largest gain was 1.7742 mg. of nitrogen for *Aspergillus* and 10.536 mg. with a culture of *Phoma* which was

grown on a decoction of beet sugar, sugar, and some nitrogen source; while the gain for *Mucor* was 2.0699 mg. Ternetz in work with the "*Oxycoccus*-Pilz" found a gain of 3.2994 mg. of nitrogen. These are the more recent researches on the subject. In 1893, Berthelot wrote that in working with *Aspergillus* he had determined a gain of 26 per cent. in a certain culture, the crop giving an absolute gain of 7 mg. The figures we have been able to obtain have shown as high as 205 mg. in one instance, the lowest amount being 1.6 mg., but the total average is 72.2 mg. for five control cultures and 48.3 mg. for cultures at the optimal stimulation. These numbers in nitrogen analysis are not open to the objection made by the critics cited above, and by others. They are indeed rather large for nitrogen determinations. Of course they include all the nitrogen in the culture, both that excreted into the nutrient solution, and that entering into the make-up of the vegetative body as well as the original supply. The largest amount gained in solution was 193.6 mg. over and above the 117.7 mg. supplied.

Proofs of accuracy in the operations may be adduced from the facts that examinations of different specimens of a felt made at times at some interval from one another gave results which varied by only a small fraction of a milligram; and examinations of the reagents at different times were fortunate in the same respect. Again, the different results constantly obtained with normal and stimulated crops, all at the same time consistent within themselves, would seem to give further indication of some success in manipulation. So that on the whole, it is hoped that this work will be considered as having measurably confirmed the results of the earlier workers with normal cultures; and also as having brought forward some data of value, namely, that while stimulated crops behave more economically with regard to their carbohydrate consumption, and while the amount of nitrogen entering into the composition of the fungal felt is relatively the same as for a normal growth, yet with regard to their nitrogen relation these stimulated cultures are less thrifty than normal ones, which, unless the nitrogen supplied them be in too great quantity, are able to use gaseous nitrogen and to bring it into chemical combination even in excess of actual need.

To explain the reason for the activity of the organism along these lines, there are these suggestions: one, that the fixation of free nitrogen and its excretion in combined form may be a function connected with fructification, since stimulated felts do not produce spores; another, which is more theoretical and yet more probable, is that the stimulated crop, driven to its most rapid metabolic activity by the stimulant, is forced to consume its carbohydrate more economically and therefore finds less energy to use in effecting the combination of the relatively inert and difficultly combinable nitrogen and so must use the more readily assimilable compound nitrogen; or again, it may be that since by the presence of the stimulant, the fungus can consume carbohydrate more thoroughly and with less waste, therefore it finds, in what would be a normal amount under ordinary circumstances, a more than necessary amount under the favoring influence of the stimulant, which would of course be then potentially a too great supply and the result would be over-feeding in this direction and therefore there would be a tendency to lessened activity in expending energy for nitrogen combination. This last hypothesis is in accord with Moore's * conclusions on the activity of the root-tubercle bacteria in fixing nitrogen when well supplied with nitrogen compounds, but not in accord with the results of those who find that the fixation of nitrogen is directly proportional to the amount of sugar at hand.

If, however, the absolute numerical results be questioned, there can surely be no doubt of the fact that stimulation serves to decrease the amount of nitrogen to be found in the nutrient substratum, while it has little or no effect upon the relative amount combined in the fungal felt. And lastly, if even these results be questioned on the ground that the *Sterigmatocystis* was not pure but mixed with a nitrogen-combining bacterium — which we consider to have been refuted by the evidence of the plate culture before mentioned — there remains still the fact that in the body of the fungus hyphae in which the normal and stimulated fungi vary so widely in appearance, the relative nitrogen content of the chemical composition remains the same.

* Moore, G. T. Soil inoculation for legumes. U. S. Dept. Agr. Bur. Pl. Ind. Bull. 71. 1905.

The conclusions, summarized, are given below:

1. The work of Puriewitsch and others who found fixation of free nitrogen by *Sterigmatocystis nigra* (*Aspergillus niger*) is confirmed.

2. The fixation of free nitrogen is lessened and finally inhibited by the presence of zinc sulphate in minute quantities.

3. The relative amount of nitrogen entering into the substance of the fungal felt remains the same for stimulated and unstimulated cultures, the differences of behavior toward nitrogen appearing in the fluid substratum.

BOTANICAL LABORATORIES, BARNARD COLLEGE,
COLUMBIA UNIVERSITY.
FEBRUARY, 1909.

Contributions to the Mesozoic flora of the Atlantic coastal plain — III. New Jersey *

EDWARD W. BERRY

(WITH PLATES 18 AND 18*a*)

The present brief contribution includes additions and corrections to our knowledge of the fossil flora of the Raritan formation of New Jersey and embraces certain results obtained during a monographic revision of this flora for the Geological Survey of that state which it is desirable to publish in advance of the completed work for the purpose of intelligent citation in connection with the investigation of similar floras from the southern coastal plain.

It is now nearly twenty years since Professor J. S. Newberry, through failing health, was compelled to stop work upon the Raritan flora. In this interval there has been no published addition to our knowledge of this flora except Dr. Arthur Hollick's admirable work in preparing Professor Newberry's manuscript for publication.

Much new material has been collected by the writer and others, all of which has been passed in review and the ranges of many of the species have been greatly extended. It is not my purpose, however, to give any extended discussion or lists of species at the present time, but simply to indicate certain taxonomic changes made necessary by the progress of our knowledge of certain forms or by our present ideas of their specific segregation. Synonymy is omitted wherever possible, as is any lengthy discussion of the species mentioned.

DICKSONIA GROENLANDICA Heer, Fl. Foss. Arct. **6**[2]: 23. *pl. 35. f. 8, 9.* 1882; **7**: 2. *pl. 48. f. 1–3.* 1883

Dicksonia borealis Heer, *op. cit.* **6**[2]: 23. *pl. 44. f. 2.* 1882. Not Heer, 1878, a distinct Jurassic type.

Anemia stricta Newb. Fl. Amboy Clays 38. *pl. 3. f. 1, 2.* 1896.

* Published by permission of the New Jersey Geological Survey.

Both of Heer's types which are here united with Newberry's species are small fragments of ultimate pinnae, which their author confesses are very similar, a fact well brought out by a comparison of the figured specimens. The material from Woodbridge, N. J., is more ample, and, as may be seen lower down on the frond, the pinnules become toothed and finally pinnatifid, a feature not shown in the scant material from Greenland. There is slight reason, however, for doubting their identity, Newberry himself having pointed out that *Dicksonia borealis* of Heer was probably identical with his Amboy Clay species.

Although common at Woodbridge, this species has not been found elsewhere in the coastal plain except for a single specimen which the writer discovered recently in the Tuscaloosa formation of Alabama. It is present at both the Atane and the Patoot horizons in Greenland.

OCCURRENCE: Woodbridge.

COLLECTIONS: New York Botanical Garden.

Asplenium raritanense sp. nov.

Frond and pinnae unknown. Pinnules small, 1.33 cm. long by 10 mm. in greatest breadth, ovate, with narrow somewhat straight-sided base, palmately divided into one terminal and two pairs of lateral, rounded, not deeply parted lobes; margin entire at base and in sinuses, sharply toothed on the lobes. Venation flabellate; about seven veins entering the base of the pinnule, these soon forking dichotomously, the ultimate divisions terminating in the marginal teeth. [PLATE 18, FIGURE 1.]

This species, which is quite unlike anything heretofore known from the Raritan formation, is unfortunately based on the single tiny pinnule figured. The general form and habit remain unknown. It is markedly distinct from any described fossil species known to the writer, although showing some points of resemblance to various arctic species referred to this genus by Professor Heer. Since the chances of more representative material being found are remote, it has seemed best to describe it under the above name.

OCCURRENCE: Hylton Pits.

COLLECTIONS: Johns Hopkins University.

Podozamites Knowltoni nom. nov.

Podozamites angustifolius (Eichw.) Schimper, Pal. Végét. **2**: 160. 1872. — Lesq. Cret. & Tert. Fl. 28. 1884; Fl. Dakota Group 27. *pl. 1. f. 4.* 1892. — Newb. Fl. Amboy Clays 44. *pl. 13. f. 1, 3, 4* (not *f. 2*). 1896. Not Schenk, 1868.

Zamites angustifolius Eichwald, Lethaea rossica **2**: 39. *pl. 2. f. 7.* 1860.

In 1872 Schimper referred the *Zamites angustifolius* of Eichwald to the genus *Podozamites*, overlooking the fact that Schenk, four years earlier, had described and named a *Podozamites angustifolius*. The natural impulse would be to dedicate this to Eichwald but Eichwald has already had a species of *Podozamites* named for him, in consequence of which the above name is proposed in honor of Dr. F. H. Knowlton, of the U. S. National Museum. This species has a wide range both geological and geographical. It is common in the Jurassic of high latitudes in Russia, Siberia, Bornholm, and Spitzbergen, and in the Upper Cretaceous indistinguishable remains are widely distributed in America. The abundant Raritan remains are long-lanceolate, 5–15 cm. in length by 0.6–1.2 cm. in width, the base narrowed to a short petiole, the summit long-pointed and the venation fine. They are similar to the leaflets of *Podozamites lanceolatus* but are usually longer, narrower, and more flexuous in outline.

OCCURRENCE: Woodbridge.

COLLECTIONS: New York Botanical Garden.

Pinus raritanensis Berry

Pinus sp. Newb. Fl. Amboy Clays 47. *pl. 9. f. 5, 6, 7, 8* (?), *17, 18* (?). 1896.

It seems very desirable that at least the leaves which are included under Newberry's *Pinus* sp. should have a specific name, since pine leaves of this type in fascicles of three occur to the southward in the coastal plain and a definite name is therefore a necessity for purposes of intelligent citation. Whether the poorly preserved cones and winged seeds which occur in the same beds are referable to the same species, it is impossible to determine, and since in the overlying Magothy formation there are two types of leaves of *Pinus* as well as quite different seeds I have placed a

query after Newberry's figures of cones and seeds in the above citation. *Pinus* seems to be confined to the upper part of the Raritan, although leaves, cones, and seeds are common in much older deposits elsewhere, going back as far as the Jurassic. Leaves are recorded from the Kome, Kootanie, Trinity, and Lakota formations; the Albian of Europe is remarkable for the large number of *Pinus*-like cones which it contains and Heer has recorded five species from the Atane beds.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Smilax raritanensis sp. nov.

Paliurus ovalis Newb. Fl. Amboy Clays 107. *pl. 23. f. 8, 9* 1896. Not Dawson, 1886.

Leaves of small size, ovate-elliptical, with entire margins, obtusely pointed apex and slightly cuneate base, 3.5–4 cm. long by 1.5–2 cm. wide. Primaries three, of medium size, diverging at acute angles from the extreme base, the laterals regularly curving upward and joining the midvein at the summit. Secondaries not visible except one or two transverse internal ones, and a few curved camptodrome external ones.

This species was identified by Professor Newberry with *Paliurus ovalis* Dawson,* which it somewhat resembles, and this latter species has been reported by Lesquereux † from the Dakota group and by Hollick ‡ from Marthas Vineyard. These occurrences may represent Dawson's species but the Raritan leaves are obviously different, being relatively shorter and broader and of an altogether different aspect.

Professor Newberry remarks of the difficulty of correlating these and other fossil species with the modern species of *Paliurus*, which usually has serrate or crenate leaves, and, while no new material has been obtained, it seems desirable to place these leaves in the genus *Smilax*, which contains many very similar modern leaves. Lesquereux describes two species of *Smilax* from the Dakota group, both of which are much larger-leaved and differ in other respects from the Raritan species.

* Dawson, Trans. Roy. Soc. Can. 3^1: 14. *pl. 4. f. 4, 8.* 1886.

† Lesquereux, Fl. Dakota Group 166. *pl. 35. f. 7.* 1892.

‡ Hollick, Mon. U. S. Geol. Surv. 50: 91. *pl. 34. f. 14.* 1907.

OCCURRENCE: Locality unknown.

COLLECTIONS: New York Botanical Garden.

MYRICA HOLLICKI Ward, Amer. Jour. Sci. **45**: 437. 1893

Myrica grandifolia Hollick, Trans. N. Y. Acad. Sci. **12**: 5. *pl. 3. f. 1.* 1892. Not Schimper, 1872.

Leaves of large size, 18–22 cm. in length by 4–6 cm. in width, broadly lanceolate, widest near the middle and tapering equally to the acuminate apex and the cuneate base. Margins entire for a short distance above the base, elsewhere sharply serrate. Petiole long and stout. Midrib also stout. Secondaries slender, very numerous, being not more than 2–3 mm. apart, branching from the midrib at angles of 45° or slightly more, subdividing and inosculating near the margin and sending branches into the marginal teeth. [PLATE 18, FIGURE 2.]

The type of this exceedingly handsome species is a single incomplete specimen collected at Tottenville, Staten Island, sixteen or more years ago and now preserved in the museum of the Staten Island Association of Arts and Sciences. A single specimen was collected from the Lower Raritan at Milltown. It is a larger, slightly broader leaf with slightly less prominent teeth but is obviously identical with the type.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum.

Quercus raritanensis nom. nov.

Quercus Johnstrupi Newb. Fl. Amboy Clays 69. *pl. 19. f. 7.* 1896. Not Heer.

Leaves ovate, subcoriaceous, apparently about 8–9 cm. in length by 4.5 cm. in width, pointed above. Margin with coarse pointed teeth, separated by rounded sinuses.

The New Jersey occurrence of this species is based on the single obscure fragment of the terminal half of a leaf figured by Professor Newberry and identified with *Quercus Johnstrupi* Heer, a Greenland species. The New Jersey form is obviously not the same as Heer's, which has pointed instead of rounded sinuses and is a smaller, more *Myrica*-like leaf, with the marginal teeth dentate rather than serrate.

The present species considerably resembles an undescribed *Quercus* from the Cretaceous of North and South Carolina but

this resemblance cannot be construed as a proof of identity because of the incompleteness of the New Jersey material, consequently the present form is here renamed in allusion to the locality from which it was collected.

OCCURRENCE: Sayreville.

COLLECTIONS: N. Y. Botanical Garden.

Populus orbicularis (Newb.) comb. nov.

Phyllites orbicularis Newb. Fl. Amboy Clays 130. *pl. 24. f. 7, 8.* 1896.

Leaves orbicular, very slightly emarginate and slightly decurrent from the rounded base to the apparently short petiole, length about 5 cm. and breadth usually two or three millimeters less than 5 cm. Margin entire. Midrib moderately stout. Secondaries camptodrome, relatively coarse, about 6 pairs, subopposite, branching from the midrib at a wide angle, less curved than in the preceding, and inclined to be somewhat flexuous.

Newberry calls attention to the resemblance of this species to *Populus hyperborea* Heer, but is quite positive that it is not related to *Populus*. The writer does not share this opinion. Unless we are prepared to discard *Populus* for *Phyllites* in a large number of cases this species should surely be referred to the former genus. It is a remarkable coincidence, referred to in the present connection only because of its general interest, that the type of Sternberg's genus *Phyllites* was very likely a true *Populus* and that *Phyllites* as a form genus for undeterminable leaves will probably have to be dropped eventually in favor of some other name.

The present species is based upon scanty but perfect material confined to the Sayreville horizon.

OCCURRENCE: Sayreville.

COLLECTIONS: N. Y. Botanical Garden.

Salix raritanensis nom. nov.

Salix membranacea Newb. Later Ext. Floras 19. 1868; Fl. Amboy Clays 66. *pl. 29. f. 12.* 1896. Not Thuill, 1799.

Leaves broadly lanceolate, often unsymmetrical, large, petiolate, length about 13 cm. and breadth at the widest part, which is toward the base, about 3 cm. Base rounded and obtuse. Apex narrowed and acute. Texture smooth and thin. Midrib slender, somewhat curved. Secondaries remote, branching from the

midrib at an angle of 45° and curving upward in parallel courses, camptodrome.

This is another species of *Salix* which it is difficult to define with precision. If the emphasis is laid upon the large size, thin texture, and rounded base, we have characters which are easily recognized and which can be made constant by elimination. It is apparently common in the Lower Raritan and has been reported by Hollick (*loc. cit.*) from Marthas Vineyard, the latter horizon probably of Magothy age. I have queried the small leaf figured by Hollick from Kreischerville, Staten Island, as it seems to be of a different consistency although it may be only a small leaf of this species. The latter author has tentatively included *Salix mattewanensis* Berry, which comes from the Magothy formation at Cliffwood, N. J., under this species. This is, in the writer's judgment, perfectly distinct and represents a much smaller, less elongated leaf, of a different consistency and venation.

Unfortunately, the original name *Salix membranacea* is preoccupied, so that it becomes necessary to propose a new name.

OCCURRENCE: Sayreville, Woodbridge, Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Salix pseudo-Hayei nom. nov.

Salix sp. Newb. Fl. Amboy Clays 68. *pl. 42. f. 6–8.* 1896.

Leaves small, relatively short and broad, ovate-lanceolate, uniformly about 3 cm. in length by 1.1–1.4 cm. in greatest breadth, which is about half way between the apex and base. Apex acuminate. Base rounded. Margin entire. Petiole short. Midrib slender and slightly curved. Secondaries fine, obscured in some specimens, five or six pairs, alternate, camptodrome, branching from the midrib at an angle of about 45° and curving upward.

This species is not uncommon in the Raritan, although Professor Newberry fails to mention the exact localities from which he collected it. Later material has come from the Lower Raritan at Milltown. It has been compared with the Dakota group species, *Salix Hayei* Lesq., and with the arctic Tertiary *Salix Raeana* Heer, both of which it resembles in general appearance. The Dakota group leaf, however, is coriaceous, with a coarse venation, blunt apex, and more narrow pointed base and is seen to be quite different from the Raritan species when careful comparisons are made.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Salix Lesquereuxii nom. nov.

Salix proteaefolia Lesq. Amer. Jour. Sci. **46**: 94. 1868. — Newb. Fl. Amboy Clays 66. *pl. 18. f. 3, 4.* 1896. Not *Salix proteaefolia* Forbes, 1829.

Salix proteaefolia longifolia Lesq. Fl. Dakota Group 50. *pl. 64. f. 9.* 1892.

Proteoides daphnogenoides Newb. *p. p.*, Fl. Amboy Clays 72. *pl. 32. f. 11* (not *f. 13, 14*). 1896.

Dewalquea grönlandica Newb. *p. p., op. cit.* 129. *pl. 41. f. 12* (not *f. 2, 3*).

Leaves ovate-lanceolate, somewhat more acuminate above than below, variable in size, ranging from 6 to 12 cm. in length and from 1.1 to 2.2 cm. in greatest width, which is usually slightly below the middle. Petiole stout, much longer than in *Salix flexuosa*, ranging up to 1.2 cm. in length. Midrib stout below, tapering above. Secondaries numerous, sometimes as many as twenty pairs; they branch from the midrib at angles of about 45° and are parallel and camptodrome.

Unfortunately, the name given this species was used for another by Forbes in 1829 so that it becomes necessary to rename it, and no name can be more appropriate than that of its distinguished describer, Leo Lesquereux, to whom it is here dedicated.

This is an exceedingly variable species, as might be expected in a *Salix*, and Lesquereux established several varieties, of which at least one, *i. e.*, *linearifolia*, is referable to *Salix flexuosa* Newb. Some of Lesquereux's forms are distinguishable with difficulty from the latter and this is especially shown in the leaves which he figures on plate 1 of his Cretaceous and Tertiary Flora. They are, however, larger and somewhat more robust, of a thicker texture and broadest near the base, from which they taper upward to an exceedingly acuminate tip. In general, *Salix Lesquereuxii* is a relatively much broader, more ovate form with more numerous and better seen secondaries and a longer petiole: It is a characteristic Cenomanian species in both the east and the west and has even been reported from the Cretaceous of Argentina by Kurtz. It is

abundant in the Raritan formation both in the lower and upper beds.

OCCURRENCE: Sayreville, Woodbridge, South Amboy.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Ficus ovatifolia nom. nov.

Ficus ovata Newb. Fl. Amboy Clays 70. *pl. 24. f. 1–3.* 1896. Not Don, 1802–03.

Leaves ovate 8–13 cm. in length by 4–7 cm. in breadth, petiolate. Apex extended, acute. Base rounded or somewhat descending. Margins entire. Principal veins three, from the base, the midrib being the stoutest and slightly flexuous. The lateral veins diverge at an angle of about 45° and curve upward, traversing somewhat more than the basal half of the leaf and connecting with branches from the lowest pair of camptodrome secondaries, of which there are several alternating pairs, which branch from the midrib at a wider angle. The laterals give off on the outside 8–10 camptodrome veins. Quadrangular areoles formed by nearly straight transverse nervilles fill all of the intervening space.

This species is very close to the same author's *Ficus Woolsoni*, which is a much less elongated, comparatively broader leaf, often with a cordate base in consequence.

The very appropriate name *ovata* is preoccupied, so that it becomes necessary to rename the Raritan species. It occurs also in the Bladen formation of North Carolina.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

Magnolia Hollicki nom. nov.

Magnolia auriculata Hollick, Bull. Torrey Club **21**: 61. *pl. 179. f. 6, 7.* 1894.—Newb. Fl. Amboy Clays 75. *pl. 58. f. 1–9, 11* (not *f. 10*). 1896. Not *M. auriculata* Lamarck, 1783.

Leaves orbicular-ovate, 4–10 cm. in length by 2–5.5 cm. in width, petiolate. Apex acute, slightly extended in one or two specimens. Base rounded occasionally, usually pronouncedly auriculate. Petiole and midrib stout. Secondaries few, 6 or 7 pairs, subopposite, camptodrome. Texture smooth and subcoriaceous.

This magnificent species is abundant and well preserved at the Woodbridge locality and Marthas Vineyard and in the Magothy

formation of Maryland. Professor Newberry was somewhat uncertain as to its relationship with *Magnolia* and compared it with *Aristolochia*, *Polygonum*, and *Toxylon*. The latter is the only genus which is at all suggestive and it furnishes no instances of auriculate bases, while this character of a base prevails in more than one modern species of *Magnolia*. The outline, consistency, and venation are all in accord in pointing to *Magnolia* as the proper generic reference.

Unfortunately, the specific name *auriculata* had been previously used by both Lamarck and Desvaux in 1783 and 1789, so that the fossil species may well be renamed in honor of Dr. Hollick, who has done so much in the elucidation of the Cretaceous floras in the vicinity of New York.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

MAGNOLIA BOULAYANA Lesq.

Magnolia Boulayana Lesq. Fl. Dakota Group 202. *pl. 60. f. 2.* 1892.

Magnolia glaucoides Hollick, Bull. Torrey Club **21**: 60. *pl. 175. f. 1, 7.* 1894. — Newb. Fl. Amboy Clays 74. *pl. 57. f. 1–4.* 1896.

Leaves narrowly elliptical, usually uniform in size and shape, 8.5–13 cm. in length and 3.5–4.5 cm. in breadth. Apex usually bluntly rounded, sometimes acute. Base similar to the apex. Petiole moderately stout, 3–4 cm. in length. Midrib moderately stout. Secondaries slender, often obsolete, about 11 pairs, equidistant, parallel, camptodrome, branching from the midrib at an angle of about 40°. Tertiaries, when seen, transverse. Texture coriaceous.

This species was described originally from the Dakota group of Kansas. Professor Newberry described the Raritan remains, which are abundant at the Woodbridge locality, as a new species and it has been kept distinct by Hollick, who recognized however, its practical identity with the Dakota group plant. There can be no question but that they belong to the same species, which is also recorded from Marthas Vineyard and Long Island and from the Woodbine formation of Texas and the Tuscaloosa formation of Alabama.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

LAUROPHYLLUM NERVILLOSUM Hollick, Mon. U. S. Geol. Surv. **50**: 82. *pl. 27. f. 6, 7.* 1907

Proteoides daphnogenoides Hollick, Ann. N. Y. Acad. Sci. **11**: 420. *pl. 36. f. 1, 3.* 1898.

Leaves of comparatively large size, oblong-lanceolate, about 15 cm. in length by about 2.6 cm. in greatest breadth, which is about midway between the apex and base. Apex acuminate. Base pointed, narrowly cuneate. Midrib short. Secondaries thin, close, parallel, branching from the midrib at angles not exceeding and usually somewhat less than 45°, ascending, nearly straight or somewhat flexuous, branching and inosculating near the margin where they merge in the tertiary venation, connected by transverse nervilles.

This species was described originally from the terminal moraine at Tottenville, Staten Island, and undoubtedly represents transported Raritan materials. Three specimens are contained in the Milltown collection and the writer has also collected it from somewhat higher horizons south of New Jersey. It is somewhat like *Laurophyllum lanceolatum* Newberry but has a markedly different venation and a less lanceolate outline. It is also quite close to *Laurophyllum elegans* Hollick, which is, however, a more slender lanceolate leaf, with narrowly produced apex and base and a somewhat coarser venation, with less close and more curved camptodrome secondaries.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum.

LAUROPHYLLUM ELEGANS Hollick, Mon. U. S. Geol. Surv. **50**: 81. *pl. 27. f. 1–5.* 1907

Laurus plutonia Hollick, Trans. N. Y. Acad. Sci. **11**: 99. *pl. 3. f. 3, 4.* 1892; **12**: 236. *pl. 6. f. 1.* 1893.

Proteoides daphnogenoides Hollick, Ann. N. Y. Acad. Sci. **11**: 420. *pl. 36. f. 2.* 1898.

Leaves elongate-lanceolate, somewhat flexuous, about 12–13 cm. in length by about 2 cm. in greatest width, which is about midway between the apex and the base; from this point they narrow gradually apically into an attenuated, acuminate, usually curved tip, and basally into a long, narrowly cuneate base. Midrib

stout, stouter than in *Laurophyllum nervillosum* Hollick. Secondaries numerous, usually less close and somewhat coarser than in the latter species, branching from the midrib at an acute angle below, which becomes more open above the base of the leaf; they are usually more curved than in *L. nervillosum* and more distinctly camptodrome. Tertiaries transverse throughout.

These leaves were recorded originally by Hollick as *Laurus plutonia* Heer and were later compared with *Laurus angusta* Heer, which latter species they resemble more than they do the former. In outline they are not unlike *Laurophyllum angustifolium* Newb., from Woodbridge, N. J., but differ decidedly in venation. They are also similar but quite distinct from *Laurophyllum nervillosum* Hollick, and *Laurophyllum reticulatum* Lesq. of the Dakota group.

The specimens outside of those recorded in the present contribution from New Jersey and those which are as yet unpublished from the region south of New Jersey, are from transported materials associated with the terminal moraine from which numerous specimens have been collected. Those from Tottenville, Staten Island, are undoubtedly of Raritan age, while those from Glen Cove may have been originally from the Magothy formation, although they are probably Raritan.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

PHASEOLITES MANHASSETTENSIS Hollick, Bull. N. Y. Botanical Garden **3**: 414. *pl. 78. f. 1, 2.* 1904

Leaves ovate-falcate, markedly unsymmetrical, 6–7.5 cm. in length by 2.4–2.8 cm. in greatest breadth, which is below the middle of the leaf. Margins entire. Apex acute. Base cuneate. Petiole short and stout. Midrib stout and curved. Secondaries fine, about 9 pairs, often obsolete, diverging from the midrib at an acute angle. [PLATE 18, FIGURE 3.]

This species was described from Manhasset Neck, Long Island, a locality which should probably be included within the Raritan formation. The species is scarcely distinguishable from *Phaseolites elegans*, described by the same author from Brooklyn, and both are very close to the Dakota group *Phaseolites formus* Lesq., in fact, it is scarcely conceivable that these extremely limited variations are not all of a single species. However, they should be

allowed to stand until more abundant and complete material is at hand for comparison. Another comparison which is suggested is with *Hymenaea dakotana* Lesq.

The Milltown leaf, of which two specimens have been found, is more suggestive of *Phaseolites elegans* in general appearance than it is of the species with which it is identified. This is due to its more slender apical portion. On the other hand, it shows the very full convex base on one side, and the more acutely branching secondaries which are considered specific characters of *Phaseolites manhassettensis*.

OCCURRENCE: Milltown.

COLLECTIONS: U. S. National Museum.

Leguminosites raritanensis sp. nov.

Leaflets large, 7.5 cm. by 5.1 cm., almost a perfect ellipse in outline, slightly emarginate at the apex. Midrib thin and straight. Secondaries numerous, nearly straight, ascending at an angle of about 45°, camptodrome, of delicate calibre and scarcely discernible. [PLATE 18, FIGURE 4.]

This species is based upon a single individual and seems properly referable to this genus. In outline it suggests some of the forms which have been referred to *Populus* but its venation is quite different. It resembles also some of the specimens referred to *Liriodendropsis*, which is simply another way of emphasizing the fact that it is a leguminous leaflet of unknown generic affinities.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Caesalpinia raritanensis sp. nov.

Elliptical leaflets about 3 cm. long and 2.2 cm. broad, with markedly emarginate apex. Midrib missing. Secondaries branching at a wide angle, almost 90°, and but slightly curved, anastomosing by broad evenly rounded loops about two thirds of the distance to the margin.

This is possibly only an extraordinarily large leaflet of *Caesalpinia Cookiana* Hollick, somewhat more elongated in outline and strictly congeneric with that species. It is, unfortunately, based upon a single imperfect specimen.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Citrophyllum gen. nov.

Fossil spermatophytes with elliptical to ovate or ovate-lanceolate, coriaceous leaves, with entire or slightly undulate margins and stout conspicuously alate petioles. Secondary venation fine, more or less immersed, regular, camptodrome. Embracing leaves of the same general character as those of the modern genus *Citrus* and very similar to them.

Citrophyllum aligerum (Lesq.) comb. nov.

Ficus aligera Lesq. Fl. Dakota Group 84. *pl. 10. f. 3–6.* 1892.—Berry, Rep. State Geologist [N. J.] for 1905, 139. 1906; Bull. Torrey Club **33**: 172. 1906.

Leaves small, elliptical to ovate or ovate-lanceolate, coriaceous, varying from 2.5 to 6 cm. in length by 1.8–3.2 cm. in breadth. Margin entire, occasionally slightly undulate. Apex rounded or obtusely acuminate. Base rounded, subtruncate or cuneate. Petiole stout, 0.7–2 cm. in length, conspicuously alate. The petiolar wings may be oblong-lanceolate or obovate; together they are from 2.5 to 5 mm. in width, averaging about 3.5 mm. Midrib stout. Secondaries fine, more or less obscured by the coriaceous leaf-substance, about 9 alternate pairs, branching from the midrib at angles of from 45 to 50°, parallel, camptodrome. [PLATE 18a, FIGURES 1–8.]

These curious leaves were described by Lesquereux from the Dakota group as a species of *Ficus* and compared with *Ficus bumelioides* Ettings. and *Ficus Mudgei* Lesq., neither of which has alate petioles, while the first has an emarginate apex. Subsequently, the same leaves were found in the Magothy formation of New Jersey and only recently a single small leaf was found in the Upper Raritan beds of South Amboy. They exhibit considerable variability in outline, but all have exactly the same aspect and conspicuous alate petioles. They appear to be related to the leaves of the modern genus *Citrus*. The latter have exactly the same texture and venation, the same variability in outline and marginal undulations, the same stout midrib and conspicuously alate petioles. In examining a suite of specimens of the latter and comparing them with the fossils the conclusion seems to be irresistible that they are related and the writer has consequently referred the fossils to a new genus with a name that emphasizes this relationship to the modern genus. All of the fossil specimens that are

at all complete are figured on PLATE 18a and two modern leaves are introduced for comparison. Possible arguments against the present view may be based on the theory that the modern alate petioles are derived from ancestors with compound leaves, in fact some modern species still have trifoliolate leaves and if this were true of the fossils as well it would require considerable rapidity of evolution in this genus previous to the Mid-Cretaceous. The modern leaves absciss from the top of the petiole and would be unlikely to occur as fossils with the petiole attached, neither can any indication of such an abscission line be made out in the fossils. This is the most difficult argument to combat. However, modern leaves are sometimes shed in their entirety and we are justified in predicating the occasional fall of leaves before maturity when the abscission layer of cells has not yet become weakened. The agency might be violent winds, the passage of large animals like some of the Cretaceous dinosaurs, or weakened conditions due to insect or fungus diseases.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Ilex amboyensis nom. nov.

Ilex? ovata Newb. Fl. Amboy Clays 98. *pl. 18. f. 2.* 1896. Not Goepp. 1852.

Leaves small, broadly lanceolate, about 4 cm. in length by 2 cm. in breadth. Apex obtuse. Base narrowed and apparently acute. Margin beset with small and large subacute teeth. Midrib moderately stout and curved. Only a few secondaries are visible; these branch from the midrib at angles of about 45° and with but slight curving run directly to the marginal teeth.

This species was based on the single specimen figured by Professor Newberry (*loc. cit.*) and no additional specimens have come to light. Professor Newberry's name was a preoccupied one and the present name is given in allusion to the general locality.

OCCURRENCE: Sayreville.

COLLECTIONS: N. Y. Botanical Garden.

Pterospermites obovatus (Newb.) comb. nov.

Protophyllum obovatum Newb. Fl. Amboy Clays 128. *pl. 38. f. 4.* 1896.

Leaf elliptical, about 12 cm. in length by 7.5 cm. in greatest breadth, which is near the middle. Margin entire. Midrib stout. Secondaries about 10 pairs, subopposite to alternate, comparatively slender and somewhat flexuous, camptodrome. Apex apparently rounded. Base contracted and then prominently auriculate, the three or four secondaries involved radiating from the base of the midrib.

This species is based upon a single specimen from Woodbridge, which Professor Newberry suggested may be related to the modern species of *Coccoloba*.

Very little can be said in favor of the reference of this leaf to Lesquereux's genus *Protophyllum*, all of the species of which differ from it in outline and marginal characters. Professor Newberry places great reliance upon the character of the base, but in the Raritan specimen this is decidedly auriculate and not subpeltate and the veins in this part of the leaf are radiate and not more or less parallel. Finally, the venation is distinctly camptodrome and not craspedodrome as it is in Lesquereux's definition of the genus and in all the other species which have subsequently been referred to it. For these reasons it is here placed in the genus *Pterospermites*, which seems to be a more natural arrangement. It may be compared with *Pterospermites auriculatus* Heer * of the Atane beds of Greenland which, while somewhat different in outline, is a leaf of the same general facies and is undoubtedly congeneric.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Garden.

EUCALYPTUS ANGUSTA Velen.

Eucalyptus angusta Velen. Fl. Böhm. Kreidef. **4**: 3. *pl. 3. f. 2–12.* 1885; Květena českého cenomanu 21. *pl. 6. f. 1.* 1889.—Sap. Fl. Foss. Portugal 207. *pl. 36. f. 12.* 1894.

"Blätter lineal, schmal lineallanzettlich, in der Mitte oder in der unteren Hälfte am breitesten, ganzrandig, vorne in eine sehr lange Spitze vorgezogen und mit einem harten Dorn beendet. Der Primärnerv gerade, ziemlich stark, zur Spitze hin verdünnt. Die Secundärnerven zahlreich, unter spitzen Winkeln entspringend, am Rande durch einen Saumnerv untereinander verbunden. Der Blattstiel gerade, etwa 1 cm. lang, stark." Velenovsky, 1885.

The foregoing is Velenovsky's description of this interesting species, which is exceeding common at a number of localities in

* Heer, Fl. Foss. Arct. **6**[2]: 95. *pl. 27. f. 4.* 1882.

the Perucer-schichten of Bohemia (Cenomanian), where the author subsequently found fruit-bearing twigs which he described and figured in 1889 and which, it would seem, conclusively establish the botanical relations of these leaves.

Subsequently, Saporta (*loc. cit.*) recorded this species from the Albian beds of Portugal; the latter material is, however, rather incomplete and open to question. Recent collections in our own coastal plain show that this species was present in considerable abundance on this side of the Atlantic at the same time that it flourished in Europe. It has been collected from the upper Raritan at South Amboy, where it is common, from the Bladen formation of South Carolina, and from the Upper Cretaceous of Georgia, and may be somewhat more fully characterized as follows:

Leaves alternate or scattered, mostly elongated, linear-lanceolate, often falcate, 4.5–15 cm. in length by 5–13.5 mm. in width, with an attenuated acute tip and a narrowly cuneate base declining to the short and stout petiole. Midrib moderately stout below, becoming attenuated above. Secondaries very numerous, fine, and close, about 1 mm. apart, parallel, rather straight; they branch from the midrib at acute angles of about 30° or slightly less and run with but slight curvature to join the well-marked but fine marginal hem, which shows in all the American material and in most of the illustrations of the foreign material. [PLATE 18, FIGURE 5.]

In all respects this is one of the most characteristically *Eucalyptus*-like species of the many which have been so identified; and its totality of characters combined with the presence of attached fruits in the Bohemian material, which are not unlike some of those of modern forms, renders the identification very satisfactory.

OCCURRENCE: South Amboy.

COLLECTIONS: U. S. National Museum.

Andromeda Cookii nom. nov.

Andromeda flexuosa Newb. Fl. Amboy Clays 121. *pl. 34. f. 1–5.* 1896. Not Moon, 1849.

Leaves coriaceous, variable in size, lanceolate, 6–12 cm. in length by 1.5–3 cm. in width, with an acuminate apex and a somewhat cuneate base. Midrib stout and flexuous. Secondaries strong, somewhat flexuous, branching from the midrib at an acute angle and arching upward in long curves, camptodrome. Tertiaries mostly simple, transverse, forming oblong areoles.

This species is of the same general character as the other Raritan species of *Andromeda*, with which it is strictly congeneric. It is a common form in the Lower Raritan, although most of the specimens are imperfect. Elsewhere it is recorded from Glen Cove, Long Island, but the material from the latter locality is not very conclusive. The name given to this species by Newberry was unfortunately preoccupied and the name here used is given in honor of the late George H. Cook, whose work on the Raritan and allied formations has furnished the basis for all subsequent studies.

OCCURRENCE: Sayreville, Woodbridge, Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Myrsine Gaudini (Lesq.) comb. nov.

Myrsinites? Gaudini Lesq. Fl. Dakota Group 115. *pl. 52. f. 4.* 1892.

Myrsine elongata Hollick, Bull. Torrey Club **21**: 54. *pl. 177. f. 2.* 1894. — Newb. Fl. Amboy Clays 122. *pl. 22. f. 1–3.* 1896.

Leaves oblanceolate or elongate-obovate, 5.5–7 cm. in length by 1.9–2.5 cm. in greatest width. Margin entire. Apex obtusely rounded. Base somewhat elongated, narrowly cuneate. Petiole present, stout. Midrib stout below, rapidly diminishing in calibre. Secondaries numerous, 8–10 pairs, alternate, branching from the midrib at angles of from 40° to 45°, camptodrome. When tertiary venation is distinctly preserved, the venation is more typical than when only the secondaries are partially visible.

This species is well distributed in the Raritan and has been recorded also from Long Island and Staten Island. The identification of *Myrsinites? Gaudini* Lesq. with the eastern forms with which it is obviously identical extends the range eastward from Kansas to Long Island. It may be readily distinguished from the other Raritan species by its relatively narrow elongated form. It is also present in undescribed collections of the writer from North Carolina and Alabama.

OCCURRENCE: South Amboy, Milltown.

COLLECTIONS: U. S. National Museum; N. Y. Botanical Garden.

Diospyros amboyensis nom. nov.

Phyllites ellipticus Newb. Fl. Amboy Clays 130. *pl. 24. f. 9.* 1896.

Leaves elliptical, large, 8 cm. long by 4–6 cm. broad. Margin undulate. Apex rounded, almost retuse. Base broadly rounded,

thus differing from the wedge-shaped base of *D. primaeva*. Midrib strong, although not so strong as in the latter species. Secondaries numerous, 8–10 pairs, regular, leaving the midrib at an angle of about 45°, camptodrome. Tertiary venation of large polygonal meshes finer in calibre than in *D. primaeva*.

Unfortunately, no specimens other than Newberry's original type have been found and it is possible that it was an aberrant leaf of the common *Diospyros primaeva*, some undoubted leaves of which suggest it in their sum of characters. One of the leaves which Heer identifies from the Atane schists of Greenland as *Populus hyperborea*,* while the apex is partially destroyed and the tertiaries are not shown, is very similar to the species under discussion. This similarity does not extend, however, to the other leaves identified as this species. Newberry's specific name having already been used for a species of *Diospyros*, it becomes necessary to rename the Raritan plant.

OCCURRENCE: Woodbridge.

COLLECTIONS: N. Y. Botanical Gerden.

Acerates amboyensis Berry

Acerates sp. Hollick in Newb. Fl. Amboy Clays 124. *pl. 32. f. 17; pl. 41. f. 4, 5.* 1896.

Leaves narrow and elongated, somewhat falcate, lanceolate or linear-lanceolate, 5–7.5 cm. in length by 5–8 mm. in breadth, gradually narrowed above and cuneate below. Margin entire, somewhat undulate. Petiole apparently wanting. Texture thick. Secondaries numerous, rather angular, branching from the midrib at acute angles, camptodrome.

There is no reason why this species should not have a specific name, if only for purposes of intelligent citation. It is, however, perfectly distinct from the other members of the Raritan flora and is easily recognized. It is confined to the Upper Raritan in New Jersey but occurs in the Bladen formation of North Carolina. Several species of *Acerates* are described by Heer from the Greenland Cretaceous.

OCCURRENCE: South Amboy.

COLLECTIONS: N. Y. Botanical Garden.

* Heer, Fl. Foss. Arct. 3^2: *pl. 29. f. 6.* 1874.

Explanation of plates 18 and 18a

PLATE 18

FIG. 1. *Asplenium raritanense* sp. nov., Hylton Pits, N. J.
FIG. 2. *Myrica Hollicki* Ward, Milltown, N. J.
FIG. 3. *Phaseolites manhassettensis* Hollick, Milltown, N. J.
FIG. 4. *Leguminosites raritanensis* sp. nov., South Amboy, N. J.
FIG. 5. *Eucalyptus angusta* Velen., South Amboy, N. J.

PLATE 18a

FIG. 1. *Citrophyllum aligerum* (Lesq.) Berry, South Amboy, N. J.
FIGS. 2–5. *Citrophyllum aligerum* (Lesq.) Berry, Cloud Co., Kansas.
FIGS. 6–8. *Citrophyllum aligerum* (Lesq.) Berry, Cliffwood Brick Company, N. J.
FIG. 9. *Citrus vulgaris* Risso, Florida.
FIG. 10. *Citrus Limonum* Risso, St. Croix.

Some unsolved problems of the prairies

HENRY ALLAN GLEASON

Of the territory now known as Illinois, probably two thirds was originally occupied by the various plant associations constituting the type of vegetation known as prairie.* Poorly developed in southern Illinois, and extending but a short distance east into Indiana or north into Wisconsin, they swept to the west across Iowa, and in Nebraska united with the main portion of the prairie province, which extends northward from Texas on the south into the British possessions. This eastern extension has been appropriately named by Pound and Clements the eastern arm of the province, and its position is shown with considerable accuracy in their paper † on "The vegetation regions of the prairie province." The Illinois prairies alone are referred to in this paper.

Unfortunately for the ecologist, the prairies of Illinois were converted into cornfields long before the development of ecology and phytogeography in America, thus forever prohibiting the *satisfactory* investigation of some questions of the most absorbing interest and also of considerable importance in aiding a clear

* Following the stimulating and valuable example of Harper (Ann. N. Y. Acad. Sci. 17 : 25. 1906) concerning the meaning of the terms "swamp" and "branch," the use and restriction of the term "prairie" may be discussed. According to the Century Dictionary, the word is derived through the French from the Latin *pratarium* or meadow-land, and was first applied by the early French explorers to the broad expanses of grassland of Illinois, Iowa, and neighboring states. The English language, developed in a forested country, had no regular word for grassland except meadow, the meaning of which was restricted by local conditions to cultivated land or to the small strips of grassland along ponds or streams. When the word prairie was adopted from the French into the English, it was still limited to the grassland of the region mentioned above ; it was and is a local term, and should be kept so. Other similar grass-covered lands in different parts of the hemisphere have received analogous names which have become more or less established in the language. Such are pampas in southern South America, llanos in northern South America, and savannas in the southeastern United States. The term prairie should be applied to none of these, nor to any other areas of grassland except those of the limited territory of the Middle West, covered by the prairie province.

† Bot. Gaz. **25** : 381–394. *pl. 21.* 1898.

understanding of American ecology and phytogeography in general. The thoroughness with which original conditions have been destroyed over central and northern Illinois is surprising to the botanists of the more densely populated, but sparsely settled East. In most of the counties of this part of the state there is absolutely no virgin prairie or forest, and in other cases the prairies are limited to narrow strips along railroads or small streams. In one case they are modified either by civilization or by burning and in the other they are not typical of the original upland prairies. Cook County, in which is located Chicago with its two million inhabitants, is mainly outside of the prairie province, but contains ten times as much unused land as do Champaign, MacLean, or Livingston counties, located in the "corn belt." On the other hand, Cook County offers poor facilities for field work in comparison with the vicinity of New York City.

The opportunity for study is, however, not entirely lost, but the investigation is made more difficult, and every succeeding season lessens the possibility of work along this line. In this paper there are merely indicated some of the particular questions that still await satisfactory solution, in the hope of awakening interest, and, if possible, stimulating research along this line. The questions are by no means entirely unanswered; every ecologist has a general idea in regard to them, but the detailed information is for the most part lacking. Our information may be drawn from a number of sources, some of which may be enumerated:

1. Books of travel and description, of which many are extant, though they are unfortunately more picturesque than scientific in their method of treatment. These begin with the published works of the early French explorers, Marquette and Hennepin, and extend to the middle of the last century. They are particularly numerous between 1810 and 1850, when the prairie country was being most rapidly settled.

2. A fairly good knowledge of the prairie flora, which we owe to Bebb, Mead, Vasey, Hall, and Brendel, of a past generation, and which may still be supplemented by direct observation along roadsides and railroads.

3. Several areas of considerable extent on which prairies are still preserved, but under abnormal conditions, such as the swampy

prairies in the Chicago area, described by Cowles,* and the sand prairies along the Illinois River,† and in other parts of northwestern Illinois.‡

4. Comparisons with the still existing prairies farther west, as described by ecologists from Iowa, South Dakota,§ and Nebraska.‖

By carefully combining observations taken from as many standpoints as possible we should still be able to reconstruct for ourselves, so to speak, the prairies of the state and to solve many of the ecological questions which they call up.

Some of the questions that have occurred to me are these:

1. What were the conditions, climatic or of other nature, at the close of the glacial epoch, which led to the invasion of prairie plants from the west rather than forest plants from the southeast? Certain climatic conditions are more favorable to the growth of prairie than of forest, notably a low winter rainfall, and it is noteworthy that this type of rainfall is quite well developed in northern Illinois, and thence west, but not in Indiana, or in southern Illinois. Transeau's interesting map,¶ comparing rainfall and evaporation, is also pertinent here. Prairie plants complete their cycle of development more rapidly than forest trees, and might enter the territory sooner on that account. But if trees had migrated to the north and west ever since the glacial period at a rate equal to their present movement, the present state of Illinois would undoubtedly, by this time, have been covered entirely with forest. If the American botanists will use more geological evidence in their work, and if it can be used here as successfully as by the German phytogeographers, Schulz for example, considerable light will be thrown on this important point. The actual cause of the

* Bot. Gaz. **31**: 73–108; 145–182. *f. 1–35.* 1901.

† Gleason, Bull. Ill. State Lab. Nat. Hist. **7**: 149–194. *pl. 8–23.* 1907.

‡ A more detailed paper on other inland sand areas of the state is now in preparation.

§ Harvey, Floral succession in the prairie-grass formation of southeastern South Dakota. Bot. Gaz. **46**: 81–108; 277–298. *f. 1–4.* 1908.

‖ Pound and Clements, *loc. cit.*

————. The phytogeography of Nebraska. Lincoln, 1900.

Thornber, The prairie-grass formation in region I. Bot. Surv. Nebr. **5**: 29–143. 1901.

¶ Forest centers of eastern America. Amer. Nat. **39**: 875–889. *f. 1–6.* 1905.

treelessness of the prairies, which has been so widely discussed by geologists and by a few botanists also, is not to be found in any of the present conditions, but in the accumulated effects of centuries of arid climate in the southwest, from which direction the plants of our prairies immigrated.*

2. The flora of the prairies of the Wisconsin glaciation in the northern part of Illinois is very different from that of the Illinoisian glaciation at the south, estimated to be eight times as old. Does this flora at the south indicate the survival of a pre-Wisconsin interglacial flora, which persisted during the Wisconsin period, or an invasion of prairie species from a different direction or at a different time, or merely an adaptation to different conditions of soil, temperature, or rainfall, or something else? So far as I know, no one has attempted to account for this peculiar feature of the Illinois flora. Personally, it seems that it must in some way be related to, or caused by, pre-Wisconsin conditions, although what those conditions were I have no idea. Certainly, an understanding of this question would aid in answering the first one also.

3. The aquatic plants surrounding the sloughs and ponds of the prairie were generally of broad distribution, or at least in no wise typical of the prairie province. The latter class of plants was usually semi-xerophytic, and occurred in the uplands. What is the significance of this? Does it throw any light upon the order of entrance of plants, and of western plants in particular, into this area?

4. The occurrence of scattered colonies of prairie species beyond the eastern limits of the province may indicate a former more extensive range of the prairie. A notable example of this is the colony on Cedar Point, near Sandusky, Ohio,† probably two hundred miles east of their normal limits. Will it be possible by careful search for such relict colonies in other places to determine what was the maximum extension of the prairie? This would aid in giving a good idea of the rate of invasion of the forest.

5. The isolated occurrence of the western plants on Cedar

* Cf. Harvey, *loc. cit.*, 84.

† Jennings, An ecological classification of the vegetation of Cedar Point. Ohio Nat. 8: 291–340. *f.* 1–22. 1908.

See also Bonser, Ecological study of Big Spring prairie, Wyandot County, Ohio. Ohio Acad. Sci. Special Paper 7. 1903.

Point may be compared with the presence of *Cristatella Jamesii* and *Lesquerella argentea* on the sand dunes along the Illinois and Mississippi rivers, many miles from the nearest reported station in Nebraska or Dakota, or of *Opuntia fragilis* in northwestern Illinois. A number of insects found there have also a similar distribution, as shown by Mr. C. A. Hart. Neither of the plants has any means of dispersal adequate to bridge over this gap, and we can only assume that at one time they had a distribution more nearly continuous. What have been the causes which have restricted them to these widely separated stations? Is it possible that there was a post-glacial period with so little rainfall that their distribution was continuous over the whole desert-like intervening territory? And if so, what other Neo-Sonoran plants also reached into Illinois at that time? Did we ever have *Echinocereus viridiflorus*, *Cactus missouriensis*, *Cucurbita foetidissima*, *Yucca glauca*, or other plants of similar habits in this state?

The preceding questions have been phytogeographical in nature rather than ecological and have to do mainly with the historical development of the prairies. Following are some that relate more directly to ecology:

6. What was the structure of the original prairie associations? The remnants of the prairie flora still existing along our railroad tracks give only a faint idea of the normal structure of the prairie vegetation. The older botanists neglected this matter almost entirely, although it was open to direct observation. So far as I know, but one botanist, C. W. Short, discusses the subject, in an article published in 1845. He mentions particularly the aggregation of individuals of one species and contradicts the idea given by popular, more impressionistic writers. "The flora of the prairies, the theme of so much admiration to those who view them with an ordinary eye, does not, when closely examined by the botanist, present that deep interest and attraction which he has been led to expect. Its leading feature is rather the unbounded profusion with which a few species occur in certain localities than the mixed variety of different species occurring everywhere." Probably the time has passed when this question could have been satisfactorily answered.

7. Within every complex of related plant associations there

are one or more definite orders of succession, leading from pioneer to climax associations. The steps in the succession follow each other in a regular series and constitute what may be called a normal succession. The normal succession for prairie associations has not yet been fully investigated. Cowles has described a portion of it in the pond-swamp-prairie series in the Chicago area,* and I have discussed some of the successions on prairie-covered dunes,† but this by no means exhausts the subject.

8. It is a matter of common knowledge that in this region the forest is everywhere pushing out upon the prairie. This matter has been investigated by but few, and we are still ignorant, if we may depend upon the published accounts of direct local observation, of the factors which tend to retard or accelerate the advance of the forest, or of the nature of the tension zone between the two associations, or of those particular species which may be called the pioneers in the forest advance.§ It may be said at this point that the forest undoubtedly invaded the prairie along two distinct lines, a hydrophytic to mesophytic advance longitudinally along the water courses, probably led by cottonwood, elm, maple, and ash, culminating in the climax flood-plain forest, and a xerophytic lateral advance along the bluffs, led by oak and hickory. Likewise we do not know what species, normally of the forest, migrated independently into the prairie and there, constituting the derived element of the prairie flora, possibly aided in resisting the encroachments of the forest. Neither do we know why the forest in central and southern Illinois invaded along the river courses, while in northern Illinois it advanced also along the morainic hills, nor what was the effect of prairie fires in checking the spread of the forest. Each of the points is still open to direct observation, to some extent at least; and by a careful study of the habitats of various forest species along country roadsides, at the margins of woods, along small streams, and in woodland pastures, we should still be able to get some idea of the structure of the original forest margin, and with it of the pioneer species in the forest advance.

---

* *Loc. cit.* 155, 156.

† *Loc. cit.* 158–171.

§ Harvey (*loc. cit.*) gives a good general summary of this subject.

For lack of a better name this type of succession may be called abnormal, to distinguish it from the normal type mentioned before.* The abnormal succession here is between Upper Austral prairies and Upper Austral forest. The prairie came in contact also with the transition zone forests at the north, and between them there is still another type of succession to be studied, even more abnormal in nature, and possibly entirely different in operation. Our Illinois prairies also approached the Lower Austral zone in southern Illinois, but there was apparently no transition between them.

These questions are by no means the only ones still awaiting investigation in the Illinois prairies. Others equally important will present themselves at once to every ecologist. Local conditions will produce local questions whose solution may throw much light on the broader problems of the prairies as a whole. Those that I have given refer entirely to the phytogeographical and associational sides of ecology. I have not touched upon any of the numerous and varied questions of individual or physiological ecology, such as light relation, water requirements, transpiration, individual or specific relations to the environment, and the like; nor have I mentioned any questions concerning the taxonomic side of the flora, which should still yield many interesting species to the modern systematist.

UNIVERSITY OF ILLINOIS,
URBANA, ILLINOIS.

* An excellent discussion of these two general types of succession has been given by Transeau in his "The bogs and bog flora of the Huron River valley," Bot. Gaz. 40: 351–375, 418–448. 1905; 41: 17–42. *f. 1–16.* 1906. See especially 41: 38.

Notes on the embryo-sac of Passiflora adenophylla

MELVILLE THURSTON COOK

(WITH PLATE 19)

While in Cuba, about two and a half years ago, the writer had occasion to make a study of the characters of the embryo-sacs and embryos of a number of tropical plants. While pursuing this work attention was called to *Passiflora adenophylla* Mast.* which was growing luxuriantly in the botanical garden of the Agricultural Experiment Station at Santiago de las Vegas. Unfortunately, a sufficient amount of material for a complete study was not secured before leaving the island. However, the facts brought out by the study were so interesting that it has been considered advisable to present them at this time.

The early stages in the formation of the embryo-sac were not observed. The four-nucleate stage (FIG. 1) did not vary from the usual form. It was about twice as long as broad and the two nuclei at the micropylar end were somewhat larger than the two at the antipodal end. In the eight-nucleate stage (FIG. 2) the sac had elongated to about three times the length of the four-nucleate sac and the antipodal half was considerably narrower than the other half. The egg was considerably larger than the two synergids, the antipodals were well defined and the two polar nuclei unite near the egg (FIGS. 2 and 4).

The pollen-tube is very prominent (FIGS. 3, 6, and 7) and the two sperm-nuclei are clearly visible after their escape into the sac (FIG. 3). Double fertilization was very evident (FIGS. 4 and 5) and was observed in a great many preparations. In fact the writer has never examined plants in which double fertilization was so conspicuous.

However, the most interesting feature of this study was the peculiar behavior of the pollen-tube, which, as previously stated, was very prominent. In the majority of cases it does not discharge its nuclei but continues its growth within the sac, eventually

* Determined by Dr. J. N. Rose, of the National Museum, Washington, D. C., where a specimen has been deposited. It is a native of Brazil.

filling it (FIGS. 6, 7, and 8) and becoming very much twisted and tangled in the process. The growth of the tube seems to be so vigorous that its entrance into the embryo-sac usually results in the complete absorption of the egg-apparatus (FIGS. 6 and 7) and eventually of the entire contents of the sac. In those cases in which the tube does not burst, the egg-apparatus begins to disintegrate immediately upon the entrance of the tube (FIGS. 6 and 7). The sac then enlarges and the tube makes a vigorous growth, enlarging in both diameter and length and eventually filling the sac with a very much tangled mass (FIG. 8), which apparently draws its nourishment from the nucellus. It stains very deeply with haematoxylin. In the material from which this study was made, this condition was the rule and not the exception. It appears that the parasitic nature of the pollen-tube in these cases has developed in excess of the usual manner and that instead of performing the function usually performed by this organ, it really prevents the formation of the embryo.

In some instances the pollen-tube acted in the usual manner (FIGS. 3 and 4) and several cases were observed in which the egg had the appearance of having been fertilized (FIG. 4). A satisfactory study of the embryo was impossible because of the lack of material.

A number of sacs were observed in which a non-cellular endosperm had been formed (FIG. 9). In no case was the endosperm and an abnormal pollen-tube observed in the same sac.

DELAWARE AGRICULTURAL EXPERIMENT STATION,
NEWARK, DELAWARE.

Explanation of plate 19

FIG. 1. Four-nucleate embryo-sac.

FIG. 2. Eight-nucleate embryo-sac.

FIG. 3. Micropylar end of the sac, showing the egg, the pollen-tube and two sperm-nuclei.

FIG. 4. Micropylar end of the sac, showing the fertilized egg, the two polar nuclei in the act of uniting, and one sperm-nucleus.

FIG. 5. Union of the two polar nuclei and one sperm-nucleus.

FIG. 6. Micropylar end of the embryo-sac, showing the entrance of the pollen-tube without rupturing, and the egg-apparatus in early stage of disintegration.

FIG. 7. Micropylar end of the embryo-sac, showing later stage in the growth of the tube and the further disintegration of the egg-apparatus.

FIG. 8. Later stage in the development of the embryo-sac, showing it almost entirely filled by the excessive growth of the pollen-tube.

FIG. 9. The endosperm.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers, at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card-issue should be addressed to the Treasurer of the Torrey Botanical Club.

Anderson, M. P. The educational organization of nature-study. Jour. N. Y. Bot. Gard. **10**: 56–63. Mr 1909.

Bachman, F. M. *Discomycetes* in the vicinity of Oxford, Ohio. Proc. Ohio State Acad. Sci. **5**: 18–70. 1909. [Special paper no. 14.]

Bailey, W. W. Crocuses. Am. Bot. **15**: 3–5. [Mr] 1909.

Barber, K. G. Comparative anatomy of fruits and seeds of certain species of *Cucurbitaceae*. Bot. Gaz. **47**: 263–310. *f. 1–53*. 17 Ap 1909.

Bartlett, H. H. *Nolina* in the South Atlantic States. Rhodora **11**: 80–82. 13 Ap 1909.

Includes *Nolina atopocarpa* sp. nov.

Batchelder, F. W. Preliminary list of plants growing without cultivation in the vicinity of Manchester, New Hampshire. Proc. Manchester Inst. Arts & Sci. **4**: 3–59. 1909.

Beardslee, H. C. Submerged willows. Torreya **9**: 77, 78. 8 Ap 1909.

Benedict, R. C. The fern collections of the New York Botanical Garden. Jour. N. Y. Bot. Gard. **10**: 75–81. *pl. 59* + *f. 11, 12*. Ap 1909.

Bennett, A. *Potamogeton pensylvanicus* Cham. et Schlect., introduced to England. Trans. & Proc. Bot. Soc. Edinburgh **23**: 311, 312. Ap 1909.

Berry, E. W. Additions to the pleistocene flora of North Carolina. Torreya **9**: 71–73. 8 Ap 1909.

Bödeker, F. *Mamillaria Ottonis* Pfeiff., und *M. Bussleri* Mundt. Monats. Kakteenk. **19**: 41, 42. 15 Mr 1909.

Brewster, W. Occurrence of the skunk cabbage in an unusual place. Rhodora **11**: 63, 64. 6 Ap 1909.

Britton, N. L. Darwin and botany. Pop. Sci. Mo. **74**: 355–360. [Mr] 1909.

Broomall, C. M. Flower pigments. Proc. Delaware County Inst. Sci. **4**: 81–84. 23 Mr 1909.

Chamberlain, C. J. Spermatogenesis in *Dioon edule*. Bot. Gaz. **47**: 215–236. *pl. 15–18* + *f. 1–3*. 23 Mr 1909.

Christ, H. Ex herbario Hassleriano: novitates paraguarienses — I. III. *Cyatheaceae*; IV. *Polypodiaceae*; V. *Schizaeaceae*. Repert. Nov. Spec. **6**: 348–351. 1 Mr 1909.
Includes new species in *Cyathea*, *Dryopteris* (3), and *Asplenium*.

Christensen, C. *Dryopteris* nova brasiliensis. Repert. Nov. Spec. **6**: 380, 381. 1 Mr 1909.
D. Heineri from São Paulo.

Clute, W. N. The study of seeds. Am. Bot. **15**: 5–9. [Mr] 1909.

Collins, F. S. New species of *Cladophora*. Rhodora **11**: 17–20. *f. 1–6*. 16 Mr 1909.
C. microcladioides and *C. graminea* from the Californian coast, *C. Howei* from Bermuda, and *C. constricta* from Jamaica.

Collins, F. S. Notes on *Monostroma*. Rhodora **11**: 23–26. 16 Mr 1909.

Collins, J. F. Weight of ice-covered twigs. Rhodora **11**: 32. 16 Mr 1909.

Collins, J. F., & Preston, H. W. Key to New England trees, wild and commonly cultivated. 1–42. Providence, 1909.

Cook, M. T. Notes on the embryology of the *Caryophyllaceae*. Ohio Nat. **9**: 477–479. *pl. 22*. 7 Ap 1909.

Cook, O. F. Pure strains as artifacts of breeding. Am. Nat. **43**: 241, 242. Ap 1909.

Copeland, E. B. New genera and species of Bornean ferns. Philippine Jour. Sci. **3**: 343–349. *pl. 1–8*. 25 Ja 1909.

Copeland, E. B. New species of *Cyathea*. Philippine Jour. Sci. **3**: 353–357. 25 Ja 1909.
Seven new Asiatic species.

Coulter, J. M. Vascular anatomy and the reproductive structures. Am. Nat. **43**: 219–230. Ap 1909.

Cox, C. F. The individuality of Charles Darwin. Pop. Sci. Mo. **74**: 344–348. [Mr] 1909.

Davis, J. A colony of *Camptosorus*. Am. Bot. **15**: 1–3. [Mr] 1909. [Illust.]

Deane, W. Notes from Shelburne, New Hampshire. Rhodora **11**: 21, 22. 16 Mr 1909.

Detmers, F. The uncultivated fiber plants of Ohio. Ohio Nat. **9**: 480, 481. 7 Ap 1909.

Durand, E. J. A discussion of some of the principles governing the interpretation of pre-Persoonian names, and their bearing on the selection of a starting point for mycological nomenclature. Science II. **29**: 670–676. 23 Ap 1909.

East, E. M. A note concerning inheritance in sweet corn. Science II. **29**: 465–467. 19 Mr 1909.

Eaton, L. O. Additional notes on plants of Chesterville, Maine. Rhodora **11**: 30, 31. 16 Mr 1909.

Eichlam, F. Beiträge zur Kenntnis der Kakteen von Guatemala — III. Monats. Kakteenk. **19**: 33–35. 15 Mr 1909.

Elmer, A. D. E. A score of new plants. Leafl. Philippine Bot. **2**: 573–594. 15 F 1909.

Emerson, J. T. Botanical observations in Iceland and Spitzbergen. Torreya **9**: 45–54. *f. 1–3*. 26 Mr 1909.

Fawcett, W., & Rendle, A. B. Some new Jamaica orchids — II. Jour. Bot. **47**: 122–129. Ap 1909.

Includes new species in *Pleurothallis*, *Epidendrum* (14), *Neo-urbania*, gen. nov., *Habenaria*, *Lepanthes*, *Campylocentrum* (3), and *Liparis*.

Fernald, M. L. A pubescent variety of *Aster dumosus*. Rhodora **11**: 31. 16 Mr 1909.

Fernald, M. L. Note on the report of *Scirpus nanus* from Vermont. Rhodora **11**: 84. 13 Ap 1909.

Fernow, B. E. The sciences underlying forestry. Forest Quart. **7**: 23–33. Mr 1909.

Forbes, S. A. The general entomological ecology of the Indian corn plant. Am. Nat. **43**: 286–301. My 1909.

Forti, A. Studi per una monografia del genere *Pyxilla* (Diatomee) e dei generi affini. Nuova Notar. **20**: 19–38. *pl. 1, 2*. Ja 1909.

Includes 2 new fossil species in *Pseudopyxilla* from Virginia.

Gibson, H. H. A cruise in the great Smokies. Hardwood Record **27**: 21–26. 10 Ap 1909. [Illust.]

Greene, E. L. Linnaeus as an evolutionist. Proc. Washington Acad. Sci. **11**: 17–26. 31 Mr 1909.

Gruenberg, B. C. Some aspects of the mycorhiza problem. Bull. Torrey Club **37**: 165–169. 27 Mr 1909.

Hackel, E Ex herbario Hassleriano: novitates paraguarienses — I. I. *Gramineae*. Repert. Nov. Spec. **6**: 341–346. 1 Mr 1909.

Includes *Panicum fultum*, *Aristida leptochaeta*, *Sporobolus tenuispica*, and *Poa pilcomayensis* spp. nov.

Hammond, H. S. Some midwinter mosses. Am. Bot. **15**: 12, 13. [Mr] 1909.

Harris, W. The timbers of Jamaica. West Indian Bull. **9**: 297–328. 1909.

Harrison, C. The plants of our hill. Am. Bot. **15**: 9–12. [Mr] 1909.

Heller, A. A. The death camas. Muhlenbergia **5**: 50–52. 31 Mr 1909.

Herriot, W. *Epigaea repens* in Waterloo County. Ottawa Nat. **22**: 259. 12 Mr 1909.

Hill, E. J. The distribution of three naturalized crucifers. Torreya **9**: 65–70. 8 Ap 1909.

Hitchcock, A. S. Catalogue of the grasses of Cuba. Contr. U. S. Nat. Herb. **12**: 183–258 + i–xi. 23 Mr 1909.

Includes new species in *Andropogon*, *Aristida* (2), *Eragrostis*, *Eriochloa*, *Ichnanthus*, *Mesosetum*, *Panicum* (2), and *Sporobolus*; also a new genus *Reimarochloa* with *Reimaria acuta* Flügge as type.

Holmes, S. J. The categories of variation. Am. Nat. **43**: 257–285. My 1909.

Hood, G. W. Distribution of the woody plants of Ohio. Ohio Nat. **9**: 469–474. 15 Mr 1909.

Hörold, R. Systematische Gliederung und geographische Verbreitung der amerikanischen Thibaudieen. Bot. Jahrb. **42**: 251–334. 2 Ap 1909.

Includes 71 new species in *Macleania* (8), *Psammisia* (13), *Semiramisia*, *Englerodoxa* gen. nov., *Thibaudia* (9), *Ceratostema* (8), *Satyria* (2), *Orthaea* (2), *Cavendishia* (22), *Themistoclesia*, *Sophoclesia* (3), and *Disterigma*.

Huntington, A. O. The beech tree. Country Life in America **16**: 57–59. My 1909. [Illust.]

Huntington, A. O. Early poisonous wild flowers. House and Garden **15**: 135, 136. Ap 1909.

Jeffrey, E. C. On the nature of so called algal or boghead coals. Rhodora **11**: 61–63. 6 Ap 1909.

Jeffrey, E. C. The progress of plant anatomy during the past decade. Am. Nat. **43**: 230–237. Ap 1909.

Keevil, J. J. Notes on orchids of a Brazilian island. Orchid Rev. **17**: 97–99. Ap 1909.

Kennedy, P. B. Studies in *Trifolium* — II. Muhlenbergia **5**: 37–46. 31 Mr 1909.

Kindberg, N. C. Note on North American *Bryineae*. Rev. Bryol. **36**: 42–44. Mr 1909.

Includes *Calligeron subsarmentosum*, *Isothecium myuroides*, and *Bryum parvulum* spp. nov. from British North America.

Kirsch, A. M. Teratological notes — I. An abnormal specimen of *Taraxacum*. Midland Naturalist **1**: 24–26. *pl. 3*. Ap 1909.

Knowlton, C. H., *& others*. Reports on the flora of the Boston district — IV. Rhodora **11**: 75–80. 13 Ap 1909.

Lambert, F. D. Two new species of *Characium*. Rhodora **11**: 65–74. *pl. 79*. 13 Ap 1909.

C. gracilipes and *C. cylindricum*, from Massachusetts.

Levison, J. J. Filling tree cavities. Mycologia **1**: 77–79. *pl.* 6. Ap 1909.

Livingston, B. E. A repeated cycle in assimilation. Plant World **12**: 66, 67. Mr 1909.

Livingston, B. E. Roles of the soil in limiting plant activities. Plant World **12**: 49–53. Mr 1909.

Lloyd, F. E. Perennial dodder: an additional note. Plant World **12**: 65, 66. Mr 1909.

Maass, C. A. *Mamillaria woburnensis* Scheer. Monats. Kakteenk. **19**: 35–38. 15 Mr 1909.

MacPherson, J. The cedar of Lebanon. Torreya **9**: 77. 8 Ap 1909.

Malme, G. O. A. Ex herbario Hassleriano: novitates paraguarienses—I. II. *Asclepiadaceae*. Repert. Nov. Spec. **6**: 346–348. 1 Mr 1909.

Morrenia Hassleriana and *Oxypetalum reflexum* spp. nov.

Mattoon, W. R. The origin and early development of chestnut sprouts. Forest Quart. **7**: 34–47. Mr 1909. [Illust.]

McCray, A. H. Removal of the showy parts of flowers as affecting fruit and seed production. Ohio Nat. **9**: 466–469. 15 Mr 1909.

Merrill, E. D. On a collection of plants from the Batanes and Babuyanes islands. Philippine Jour. Sci. **3**: 383–442. 25 Ja 1909.

Merrill, E. D. Philippine *Ericaceae*. Philippine Jour. Sci. **3**: 369–382. 25 Ja 1909.

Merrill, E. D. The Philippine species of *Garcinia*. Philippine Jour. Sci. **3**: 359–368. 25 Ja 1909.

Moore, E. The study of winter buds with reference to their growth and leaf content. Bull. Torrey Club **37**: 117–145. *pl. 9–11* + *f. A–K*. 27 Mr 1909.

Morrison, G. L. Some crocuses grown in a New York room. Torreya **9**: 78. 8 Ap 1909.

Murrill, W. A. Collecting fungi in Jamaica. Jour. N. Y. Bot. Gard. **10**: 21–39. *pl. 57*. *f. 1–10*. F 1909.

Murrill, W. A. Illustrations of fungi — II. Mycologia **1**: 37–40. *pl. 3*. Ap 1909.

Illustrates *Agaricus campestris*, *Pluteus cervinus*, *Coprinus comatus*, *C. atramentarius*, *C. micaceus*, and *Collybia velutipes*.

Nash, G. V. The Ames collection of Cypripediums. Jour. N. Y. Bot. Gard. **10**: 63–68. Mr 1909.

Nehrling, H. Die *Amaryllis* oder Rittersterne (*Hippeastrum*). i–v + 1–71. *f. 1–16*. 1909.

Nieuwland, J. A. Notes on the priority of certain plant names. Midland Naturalist **1**: 16–21. Ap 1909.

Nieuwland, J. A. Resting spores of *Cosmarium bioculatum* Breb. Midland Naturalist **1**: 4–8. *pl. 1*. Ap 1909.

Nieuwland, J. A. The mounting of algae. Bot. Gaz. **47**: 237, 238. 23 Mr 1909.

Olsson-Seffer, P. Hydrodynamic factors influencing plant-life on sandy sea-shores. New Phytol. **8**: 37–51. F 1909.

Osborn, H. F. Life and works of Darwin. Pop. Sci. Mo. **74**: 315–343. Mr 1909. [Illust.]

Pearl, R. A note on the degree of accuracy of biometric constants. Am. Nat. **43**: 238–240. Ap 1909.

Pease, A. S. A *Juncus* new to New England. Rhodora **11**: 31. 16 Mr 1909.

Pease, A. S. Certain railroad weeds of northern New Hampshire. Rhodora **11**: 30. 16 Mr 1909.

Pease, A. S. *Cryptogramma Stelleri* in New Hampshire. Rhodora **11**: 64. 6 Ap 1909.

Peck, C. H. New species of fungi. Bull. Torrey Club **37**: 153–157. 27 Mr 1909.

Includes 10 new species in *Eccilia*, *Clitopilus*, *Boletus*, *Herpotrichia*, *Botrytis*, *Gyroceras*, *Cercospora* (2), and *Fusarium* (2).

Pennell, F. W. Some additions to Dr. Fussell's list of Delaware County plants. Proc. Delaware County Inst. Sci. **4**: 68–74. 23 Mr 1909.

Purpus, J. A. *Cereus Schenckii* Purp. n. sp. Monats. Kakteenk. **19**: 38–41. 15 Mr 1909.
Native in Mexico.

Ramaley, F., & Robbins, W. W. Studies in lake and streamside vegetation. Univ. Colorado Studies **6**: 133–168 + i–iv. F 1909. [Illus.]

Robinson, B. L., & Fernald, M. L. Emendations of the seventh edition of Gray's manual — I. Rhodora **11**: 33–61. 6 Ap 1909.

Robinson, W. J. Experiments on the effect of the soil of the Hemlock Grove of the New York Botanical Garden upon seedlings. Jour. N. Y. Bot. Gard. **10**: 81–87. *f. 13*. Ap 1909.

Roland-Gosselin, R. *Cactaceae* novae. Bull. Soc. Bot. France **55**: 694–696. 6 F 1909.
Rhipsalis himantoclada, native in Costa Rica, and *Cereus Dybowskii*, native in Brazil.

Rolfe, R. A. New orchids: decade 33. Kew Bull. Misc. Inf. **1909**: 61–66. Mr 1909.
Includes 4 new American species in *Octomeria*, *Cynoches*, *Ornithidium*, and *Sobralia*.

Rose, J. N. Studies of Mexican and Central American plants — no. 6. Contr. U. S. Nat. Herb. **12**: i–ix + 259–302. *pl. 20–27* + *f. 20–48*. 12 Ap 1909.
Includes the new genera *Pelozia*, *Pseudolopezia*, and *Jehlia*, of the *Lopezieae*, and 74 new species in *Cycadales*, *Gnetales*, *Liliaceae* (2), and numerous families of dicotyledons (70).

Schaffner, J. H. The classification of plants — V. Ohio Nat. **9**: 489–494. 7 Ap 1909.

Schaffner, J. H. The reduction division in the microsporocytes of *Agave virginica*. Bot. Gaz. **47**: 198–214. *pl. 12–14*. 23 Mr 1909.

Schulz, O. E. Ex herbario Hassleriano: novitates paraguarienses — I. VI. *Erythroxylaceae*. Repert. Nov. Spec. **6**: 352. 1 Mr 1909.
Erythroxylum pachyneurum sp. nov.

Seaver, F. J. The *Hypocreales* of North America — I. Mycologia **1**: 41–76. *pl. 4, 5*. Ap 1909.
Includes *Nectria Papilionacearum* and *Ophionectria cylindrothecia* spp. nov.

Shaw, C. H. Vegetation and altitude. Plant World **12**: 63–65. Mr 1909.

Shear, C. L. The present treatment of monotypic genera of fungi. Bull. Torrey Club **37**: 147–151. 27 Mr 1909.

Sheldon, J. L. Notes on *Uromyces*. Torreya **9**: 54–56. 26 Mr 1909.

Skan, S. A. *Arbutus Menziesii* Curt. Bot. Mag. **5**: *pl. 8249*. Ap 1909.

Small, J. K. Additions to the flora of peninsular Florida. Bull. Torrey Club **37**: 159–164. 27 Mr 1909.

Includes 5 new species in *Thysanella*, *Warea*, *Cracca*, *Goniostachyum*, and *Melanthera*.

Small, J. K. Exploration in the Everglades. Jour. N. Y. Bot. Gard. **10**: 48–55. Mr 1909.

Smith, H. H. New stations for European plant immigrants. Torreya **9**: 79. 8 Ap 1909.

Smith, J. D. Undescribed plants from Guatemala and other Central American republics — XXXI. Bot. Gaz. **47**: 253–262. *f. 1*. 17 Ap 1909.

Includes 17 new species in *Magnolia*, *Marila*, *Leandra*, *Hoffmannia*, *Guettarda*, *Chomelia*, *Satyria*, *Gonolobus* (2), *Merinthopodium*, *Neotuerckheimia*, gen. nov. (2), *Justicia*, *Ruprechtia* (2), *Daphnopsis*, and *Euphorbia*.

Somes, S. P. A freak dandelion. Am. Bot. **15**: 27. [Mr] 1909.

Standley, P. C. A witch's broom of the desert. Plant World **12**: 61–63. Mr 1909.

Standley, P. C. Herbarium notes. Torreya **9**: 74–77. 8 Ap 1909.

Standley, P. C. New or noteworthy plants from Arizona. Muhlenbergia **5**: 46–49. 31 Mr 1909.

Includes *Castilleja Blumeri* sp. nov. from Arizona.

Stapf, O. The herbarium Savatier. Kew Bull. Misc. Inf. **1909**: 148–150. Ap 1909.

Stevens, F. L., & Hall, J. G. Eine neue Feigen-Anthraknose (Colletotrichose). Zeitschr. Pflanzenkrankh. **19**: 65–68. 1 Ap 1909.

Stevens, F. L., & Hall, J. G. Hypochnose of pomaceous fruits. Ann. Myc. **7**: 49–59. *f. 1–6*. F 1909.

Stockdale, F. A. Fungus diseases of cocoanuts in the West Indies. West Indian Bull. **9**: 361–381. 1909.

Stokey, A. G. The anatomy of *Isoetes*. Bot. Gaz. **47**: 311–335. *pl. 19–21*. 17 Ap 1909.

Sumstine, D. R. Notes on mushroom spores. Science II. **29**: 621. 16 Ap 1909.

Theissen, F. *Xylariaceae* austro-brasiliensis. Ann. Myc. **7**: 1–18. F 1909.